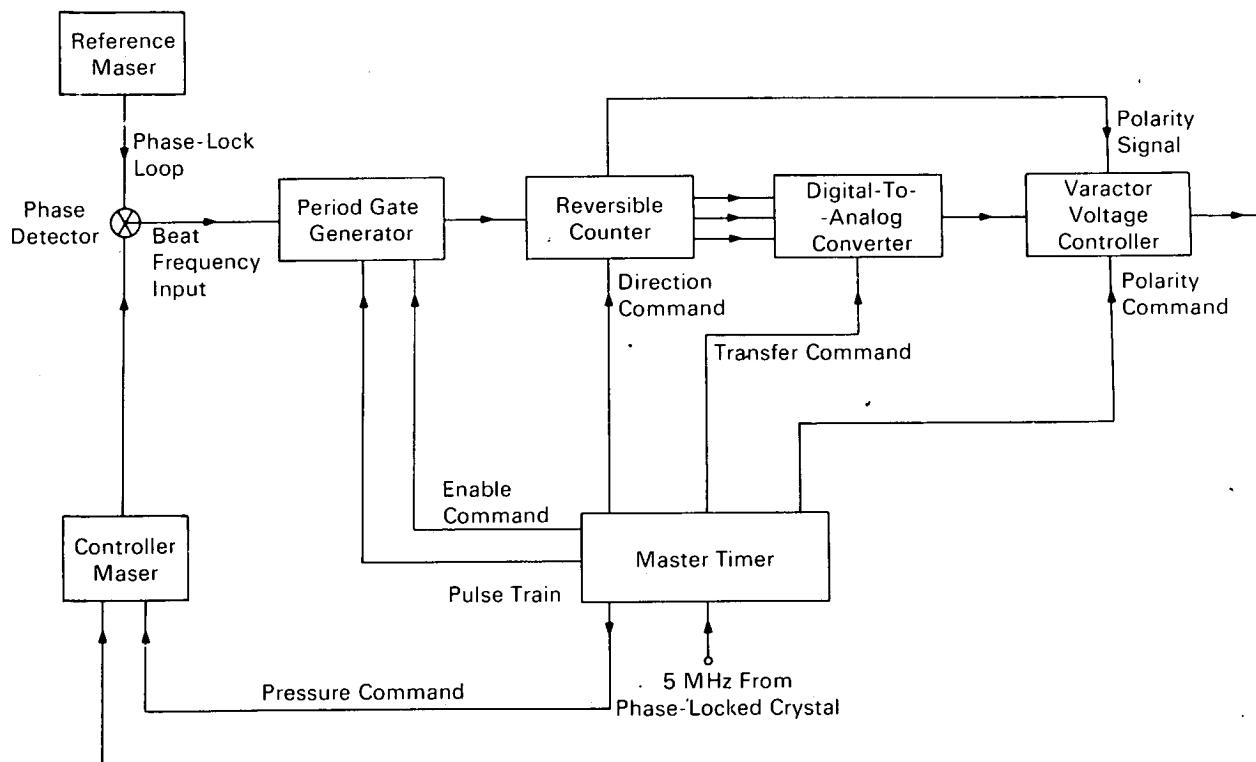


# NASA TECH BRIEF



NASA Tech Briefs are issued to summarize specific innovations derived from the U.S. space program, to encourage their commercial application. Copies are available to the public at 15 cents each from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

## Automatic Tuning of Hydrogen Masers



Block Diagram of Automatic Tuning System.

### The problem:

In the atomic hydrogen maser frequency standard, the output frequency is primarily determined by the two ground state energy levels in an aggregate of hydrogen atoms which radiate energy into a resonant cavity. This aggregate of atoms is equivalent to an oscillator of extremely high  $Q$  in the order of  $10^9$ . Mistuning of the maser rf cavity pulls the output frequency by a small amount proportional to the ratio

of the cavity  $Q$  to the atomic  $Q$ . The proper output frequency is obtained when the cavity is at the atomic resonant frequency and the problem is automatically to maintain the cavity at the proper frequency.

### The solution:

The  $Q$  of the atoms can be changed by varying the density of the atoms in the cavity. When the cavity is mistuned, the density variation causes a frequency

(continued overleaf)

variation proportional to the degree of cavity mistuning.

#### How it's done:

The frequency variations caused by varying the Q of the atoms are measured by comparing the maser with a reference oscillator. The period of the comparison beat frequency is determined by counting, in a reversible counter, a train of pulses that are gated on and off by the zero crossings of the beat. The pulses are counted in the *plus* direction when the atomic density is low and in the *minus* direction when the atomic density is high. The residual count that remains in the counter register after such an operation is proportional to the difference in the beat periods obtained at high and low density and consequently to the extent of cavity mistuning. The residual count is converted by a digital-to-analog converter to a dc voltage that is applied to a varactor diode which corrects the frequency of the activity. In the ensuing tuning cycles the register of the reversible counter is not reset to zero, the cycle repeats, and the tuning continues until there is no further change in the tuning register.

#### Note:

The following documentation may be obtained from:

The Clearinghouse for Federal  
Scientific and Technical Information  
Springfield, Virginia 22151  
Single document price \$3.00  
(or microfiche \$0.65)

Reference: NASA CR-94937 (N68-25901),  
Atomic Hydrogen Maser for Space Vehicle  
Application

#### Patent status:

Please furnish.

Source: R. Vessot and M. Levine of  
Hewlett-Packard  
under contract to  
Goddard Space Flight Center  
(GSC-10127)